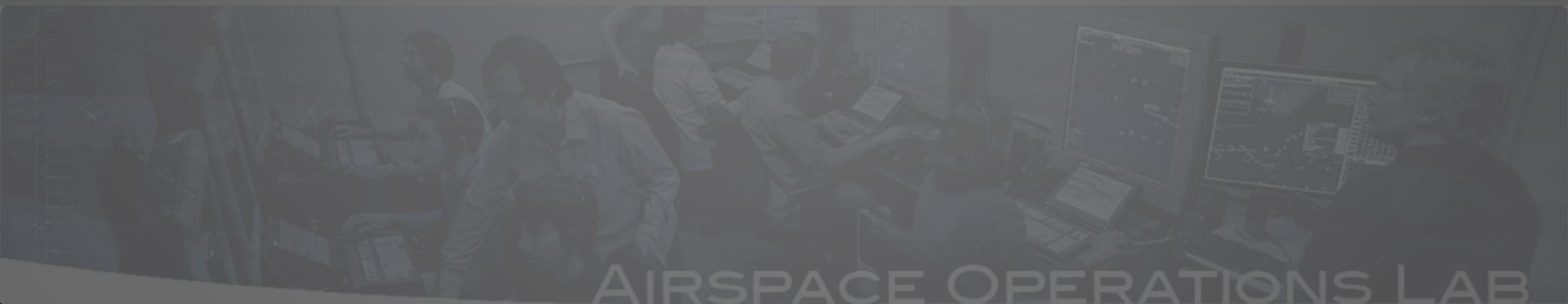
MACS Overview

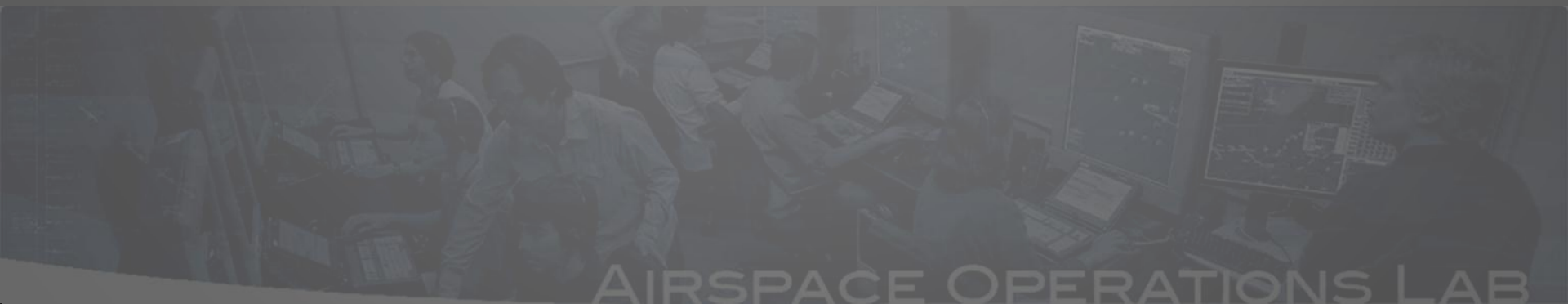
Tom Prevot

NASA Ames Research Center



Overview

- MACS Use
- Capabilities
- Software
- What to expect in this workshop



Multi Aircraft Control System (MACS)

What is MACS?

- Research software
  for simulating and evaluating air traffic operations

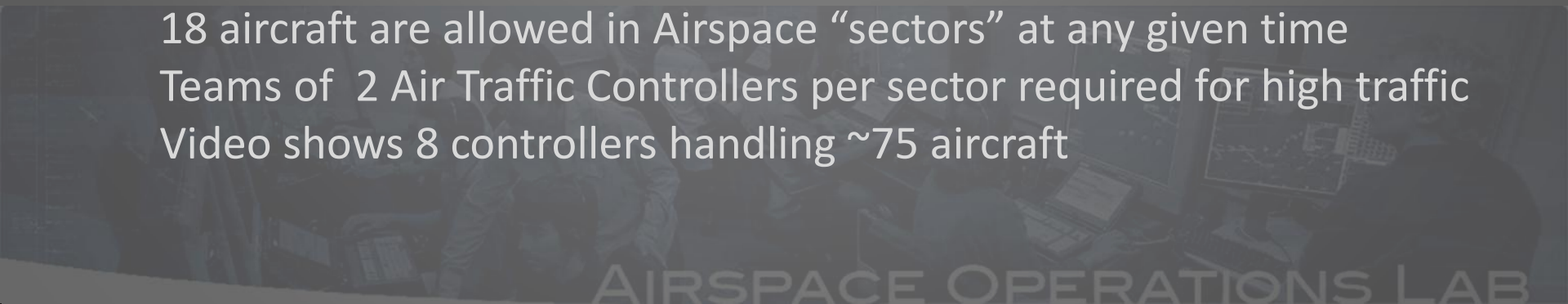
Intended Use

- Provide a better understanding of roles, responsibilities, and requirements for human operators and automation in future air traffic management (ATM) systems.
- Develop and evaluate operational concepts and technologies for the Next Generation Air Transportation System (NextGen) in a high-fidelity human-in-the-loop (HITL) environment.

Multi Aircraft Control System (MACS)

AIR TRAFFIC CONTROL OPERATIONS NEAR-TERM / 2016

18 aircraft are allowed in Airspace “sectors” at any given time
Teams of 2 Air Traffic Controllers per sector required for high traffic
Video shows 8 controllers handling ~75 aircraft

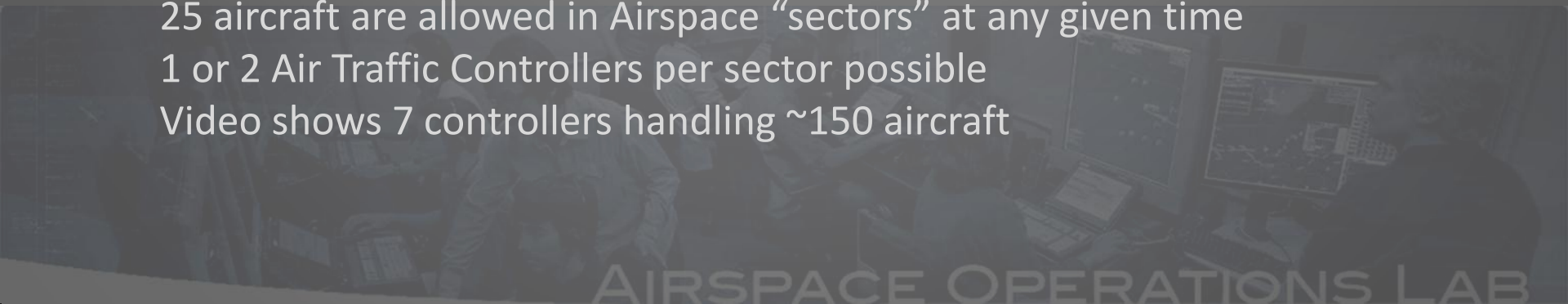


Air Traffic Control

Multi Aircraft Control System (MACS)

AIR TRAFFIC CONTROL OPERATIONS MID-TERM / 2022

25 aircraft are allowed in Airspace “sectors” at any given time
1 or 2 Air Traffic Controllers per sector possible
Video shows 7 controllers handling ~150 aircraft



Air Traffic Control in the Mid-Term

Multi Aircraft Control System (MACS)

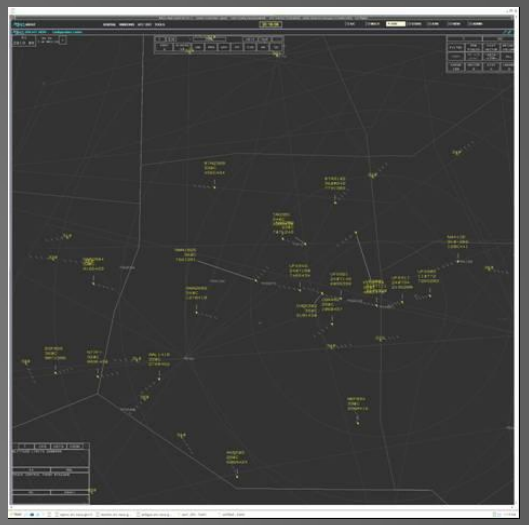
AIR TRAFFIC CONTROL OPERATIONS FAR-TERM / 2030

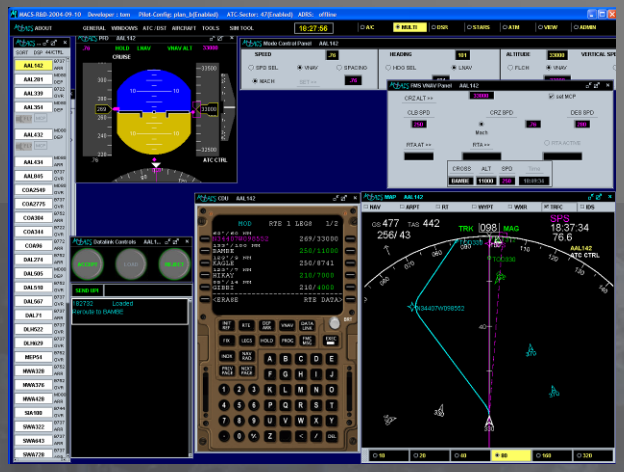
30, 40, or 50 aircraft are allowed in Airspace “sectors” at any given time
1 or 2 Air Traffic Controllers per sector possible
Video shows 8 controllers handling ~300 aircraft

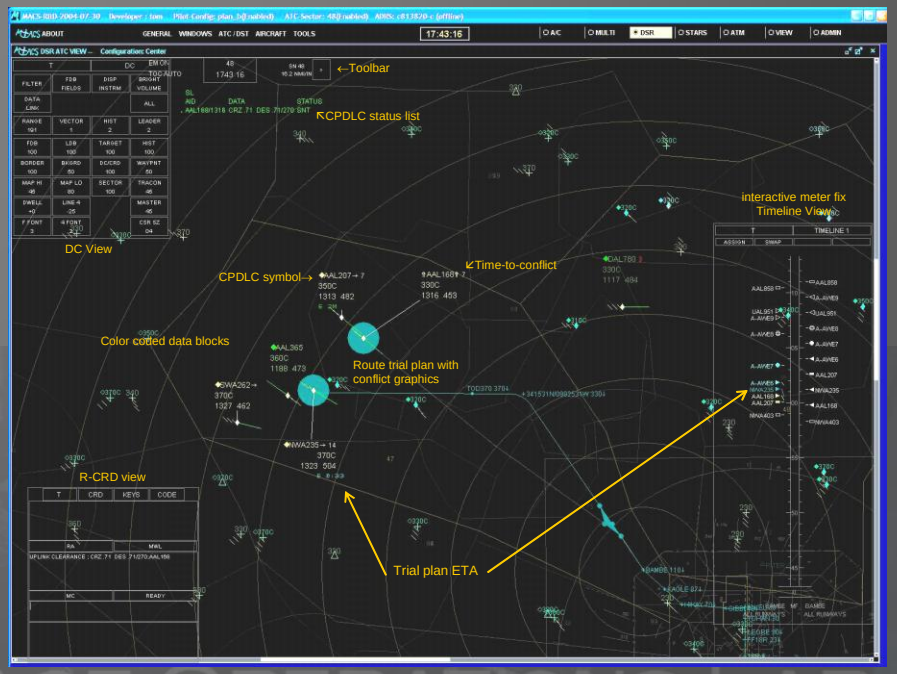
Air Traffic Control in 2030 …

RECAP: What is MACS ?

- Portable JAVA program that emulates and simulates current and future air traffic operations in the NAS
- A comprehensive environment for large scale and small scale real-time integrated air/ground simulations
  - From standalone laptop application to 50+ networked operator stations
- Rapid prototyping environment and test bed for future air traffic concepts
  - ATC/ATM automation and interfaces
  - Flight deck automation and interfaces
  - Air/ground technologies and procedures
- System for education and training





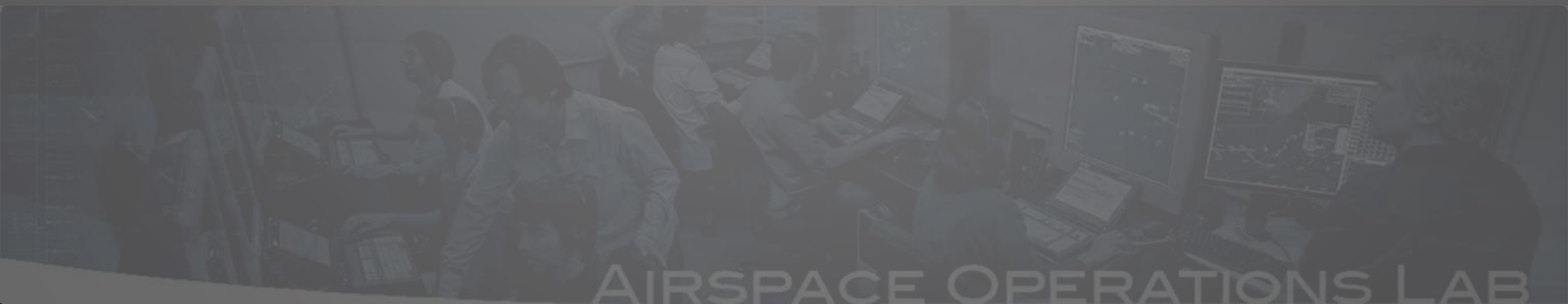


What is the Main Idea?

- All operators (human and automation) look at the same situation from different viewpoints
  - MACS maintains a central representation of the air traffic situation and provides access to all the objects stored therein
  - The different viewpoints are realized through a variety of displays and input devices
- All operators (human and automation) need to perform many of the same functions
  - MACS provides a knowledge-base with classes and methods for commonly used functions like route parsers, trajectory generators, performance calculators, etc.
  - Displays and automation access the common knowledge-base tailored to their task

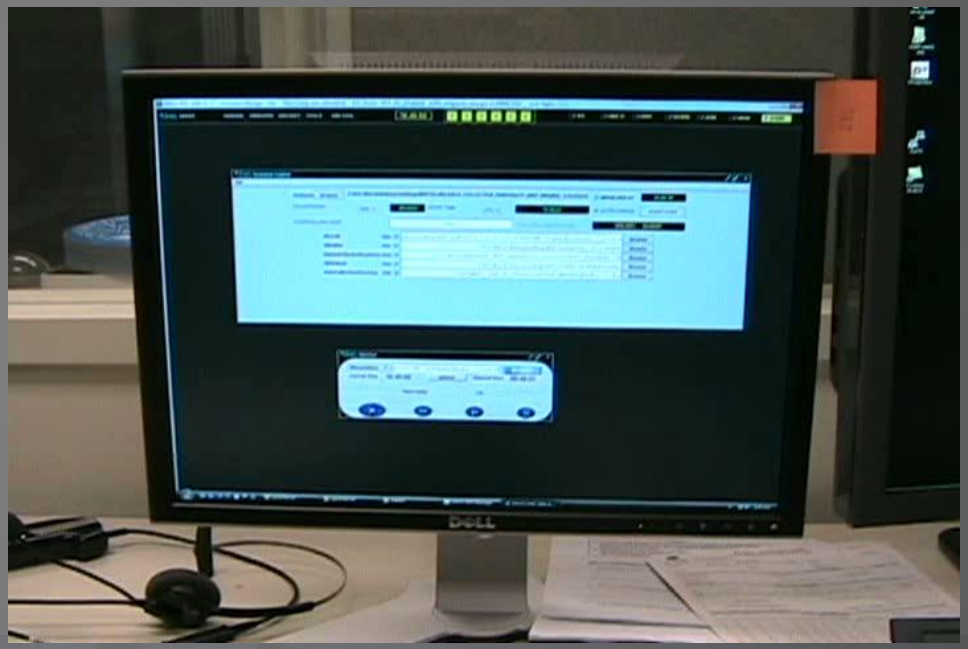
Multi Aircraft Control System (MACS)

CAPABILITIES



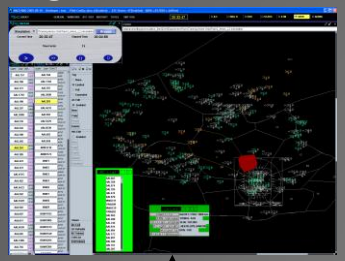
MACS Simulation in the AOL

- Experiment management
- Scenario Generation
- Flight decks and flight management
- Air traffic management
- Air traffic control (domestic, oceanic, approach)
- Advanced Automation
- Weather

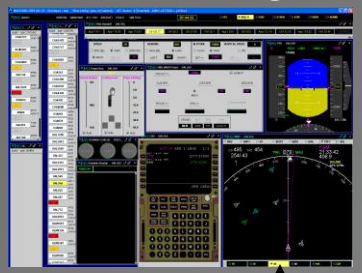


MACS Capabilities

Air traffic simulator /target generator

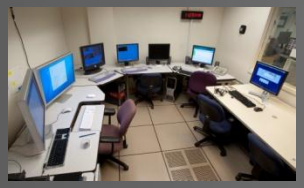


Multi aircraft autonomous agent



Multi aircraft control flight deck

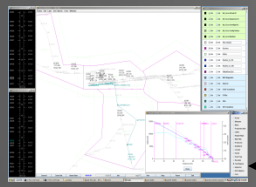
Single aircraft flight deck (B777 style)



Experiment control

Traffic and weather generation

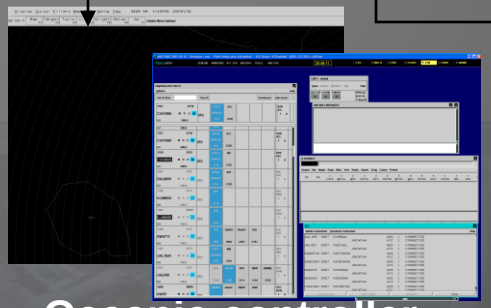
Aeronautical Datalink and Radar Simulator (ADRS) comm. network



Data collection Analysis

Center controller workstation (DSR)

TRACON controller workstation (STARS)

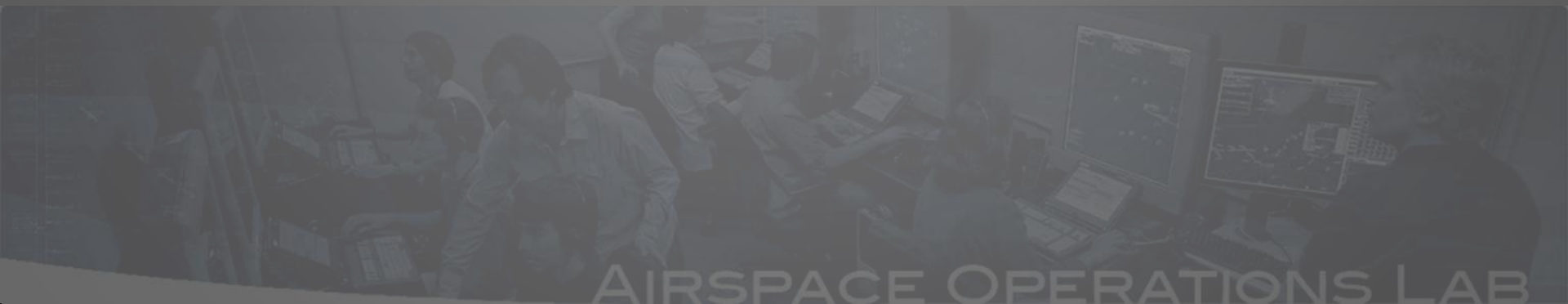


Oceanic controller workstation (ATOP/Ocean21)

Traffic flow and airspace management workstations

Multi Aircraft Control System (MACS)

REAL-TIME CAPABILITIES



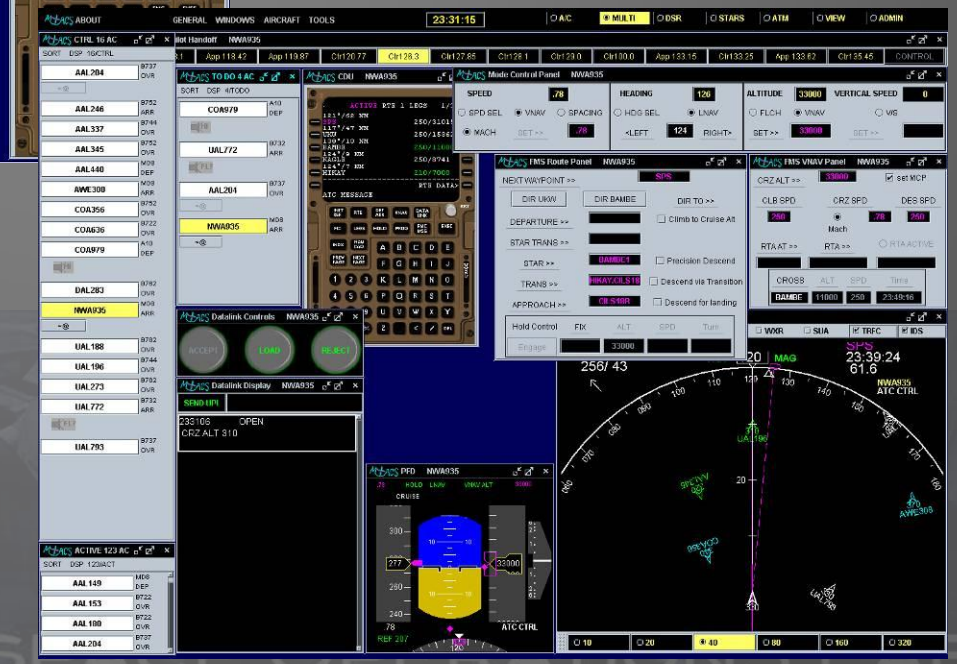
Aircraft Simulation and Flight Deck Displays

Aircraft Simulation and Flight Deck Displays

- Full flight simulator
- Selectable dynamics model (Motion Predictor, 4DOF/PAS-Aero, …)
- Flight deck for external target generator
- Performance models for the majority of current aircraft types
- Selectable equipage
- Glass cockpit displays
- Full FMS capabilities with RTA (Also used in Standalone mode)
- ASAS spacing and merging logic
- Conflict detection logic for (airborne self-separation)
- FANS – style CPDLC interface
- Interface to advanced Cockpit Display of Traffic Information (CDTI)
- Automatic processing of selected data link messages with predefined delays
- Agent support for pseudo pilots (reminders or automation)

Aircraft Simulation and Flight Deck Displays

MACS pilot interface with FDDRL's Cockpit Situation Display (CSD) for participant pilot working one aircraft



MACS pilot interface for a pseudo pilot working multiple aircraft simultaneously

ATSP capabilities and workstations

ATSP capabilities and workstations

- Highly Advanced NextGen automation:
  - Multi-layered rapid feedback conflict probing
  - Weather penetration probe
  - Data comm. integration
  - Fully automated, semi-automated, manual operations
  - AAC Auto-Resolver with Weather avoidance *(Erzberger et al.)
    - Interactive and closed loop automated
  - TSAFE conflict resolver (Erzberger & Heere)

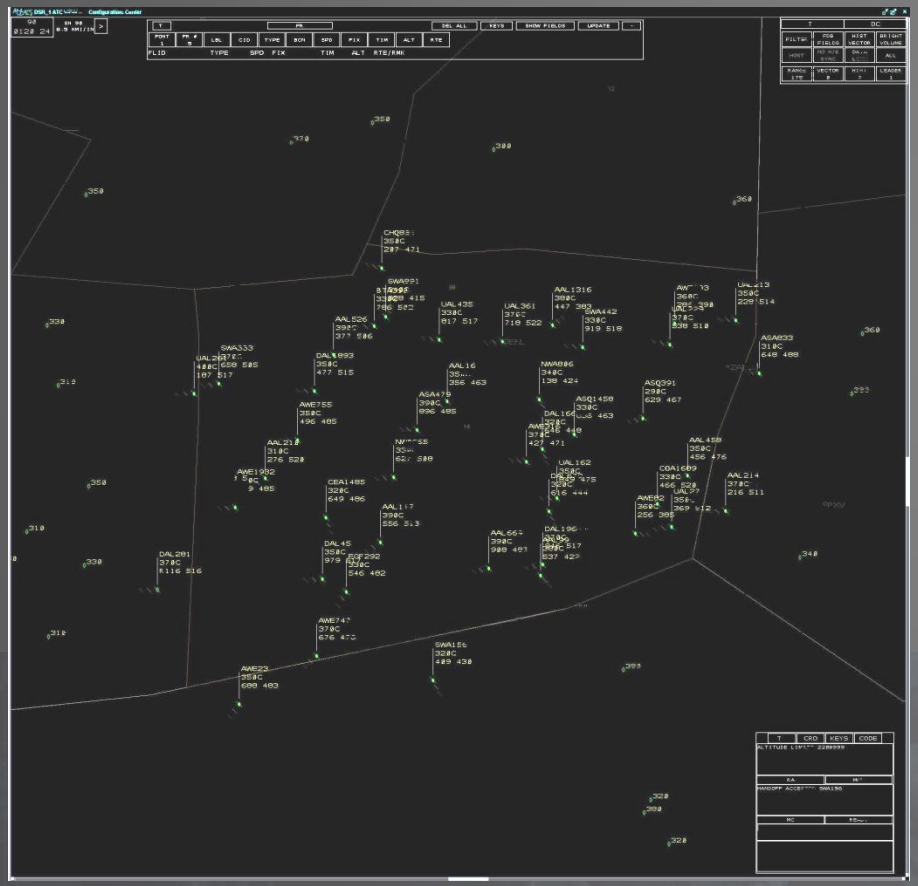
- New Paradigms in Display Design
  - High-lighting/ low-lighting scheme with interactive filters
  - Multi Aircraft Selection and command processing
  - Multi aircraft trial planning

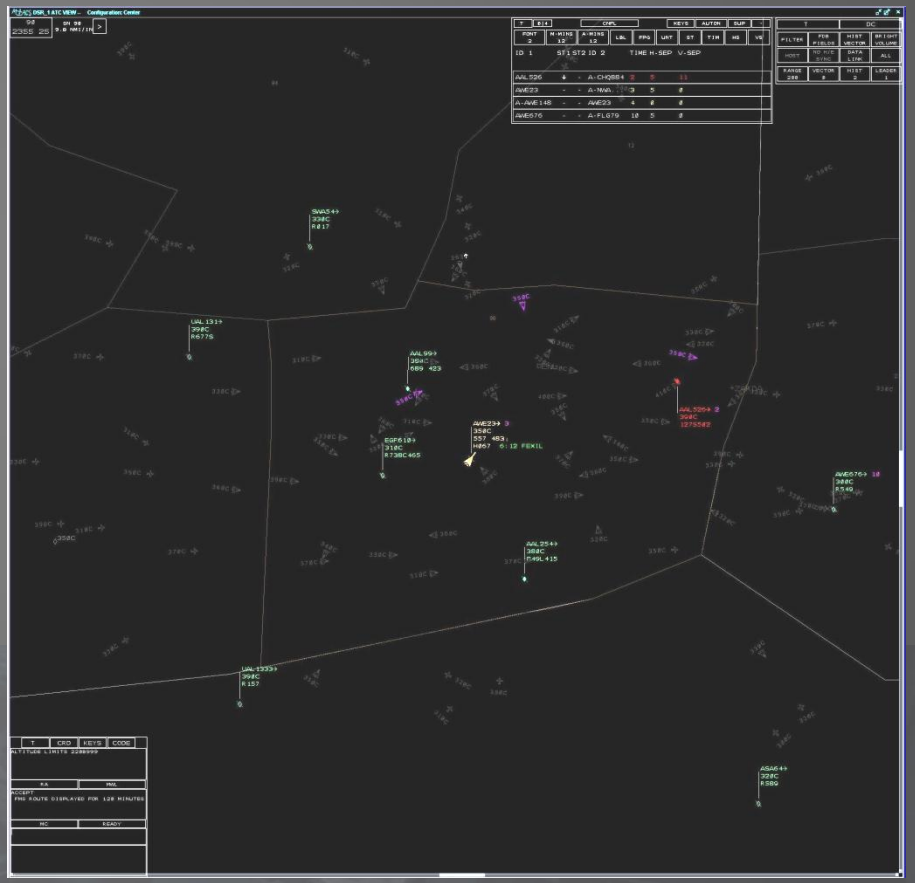
- Complexity Management
  - Interactive graphs and tables for various complexity factors

ATSP capabilities and workstations

- NAS Controller workstation emulations:
  STARS, DSR, ATOP/Ocean 21, ERAM to come
- Selectable data sources:
  - Perfect, Center radar, TRACON radar, ADS-B
- Multi-Center adaptation
- Advanced ATSP automation:
  - 4D trajectory generation for flight plan routing, scheduling, reported FMS trajectories, ADS-B reported state and flight control system targets
  - Arrival scheduler and timelines
  - Medium-term Conflict detection
  - Trial planning and speed advisory functions for metering support
  - Automation for automatic transfer of communication and RTA uplinks

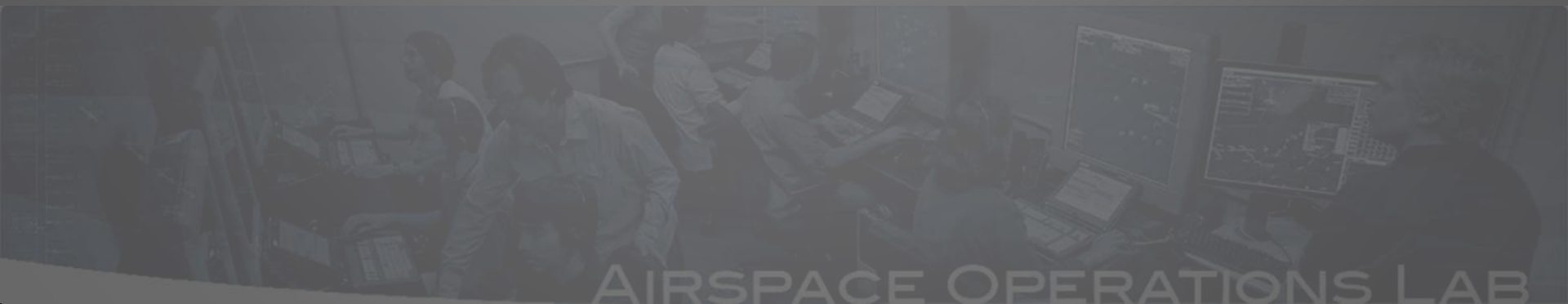
ATSP capabilities and workstations





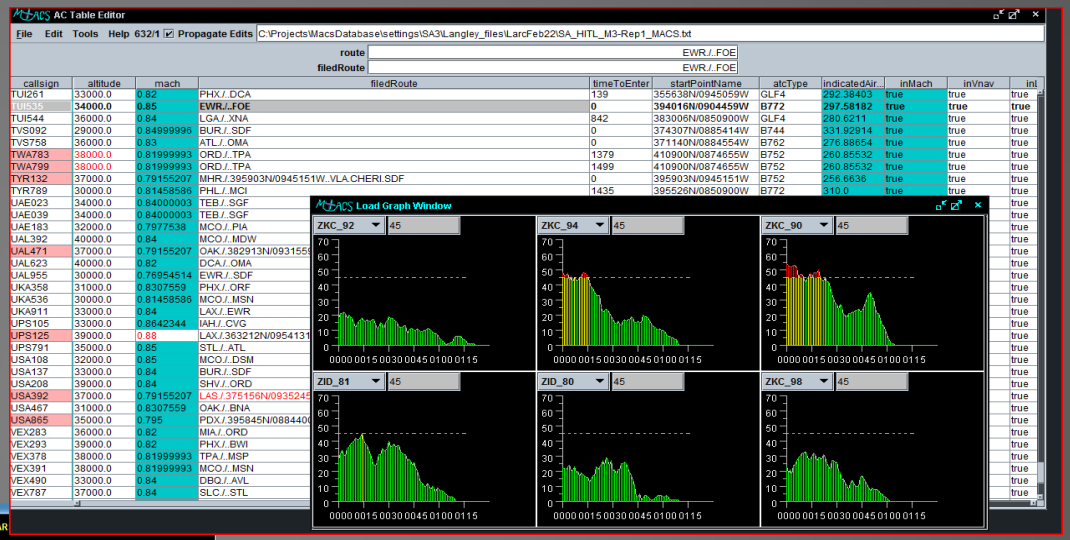
Multi Aircraft Control System (MACS)

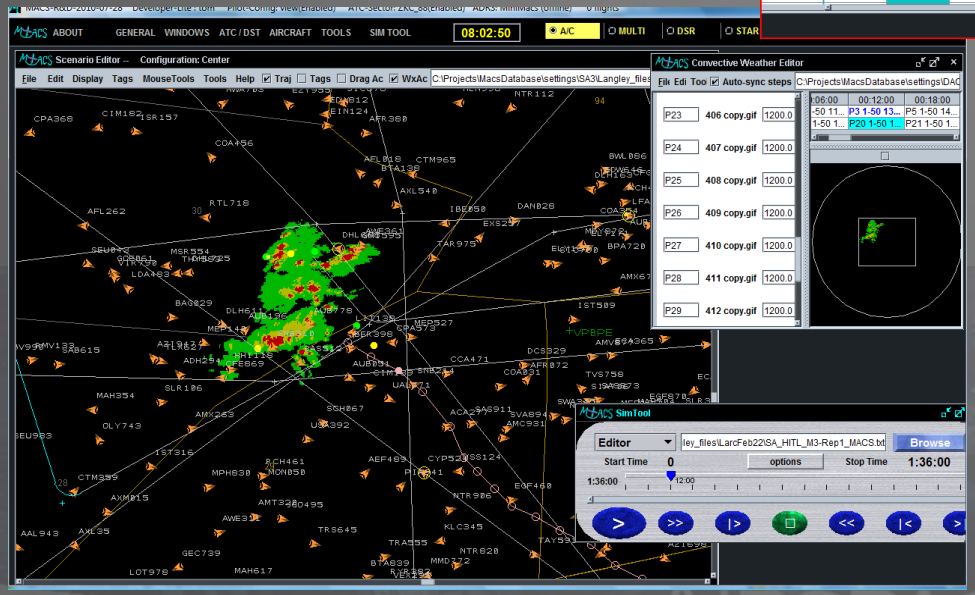
OFF-LINE CAPABILITIES



MACS Scenario Editor

- Spreadsheet-style editor
  - Error checking and correction
  - Automatic functions
  - Load graphs

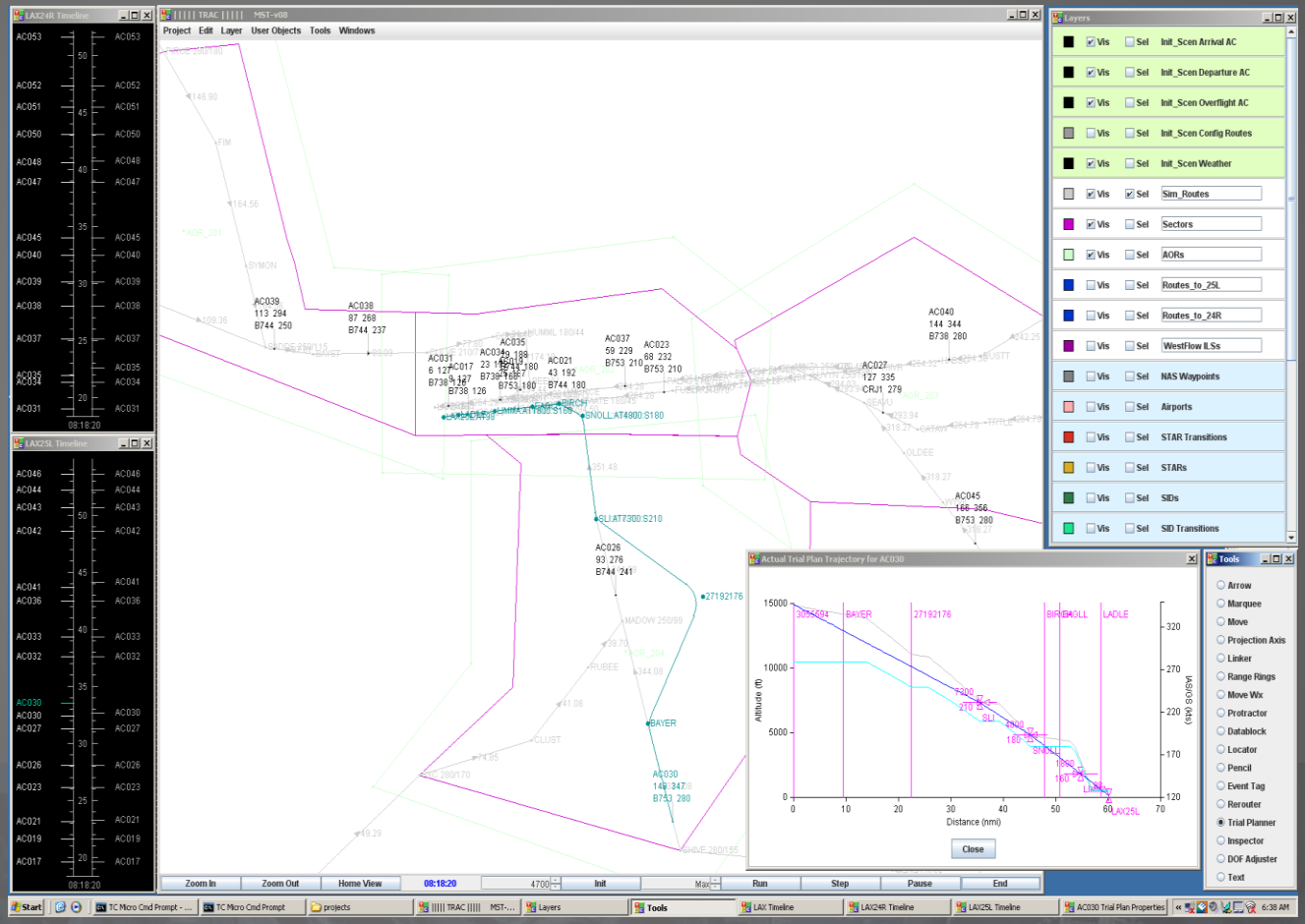




- Graphical editor
  - **Trajectories for aircraft and convective weather**
  - Time slider
  - **Weather and conflict probing**
  - Trajectory planning

TRAC
(TCSim Route Analyzer/Constructor)

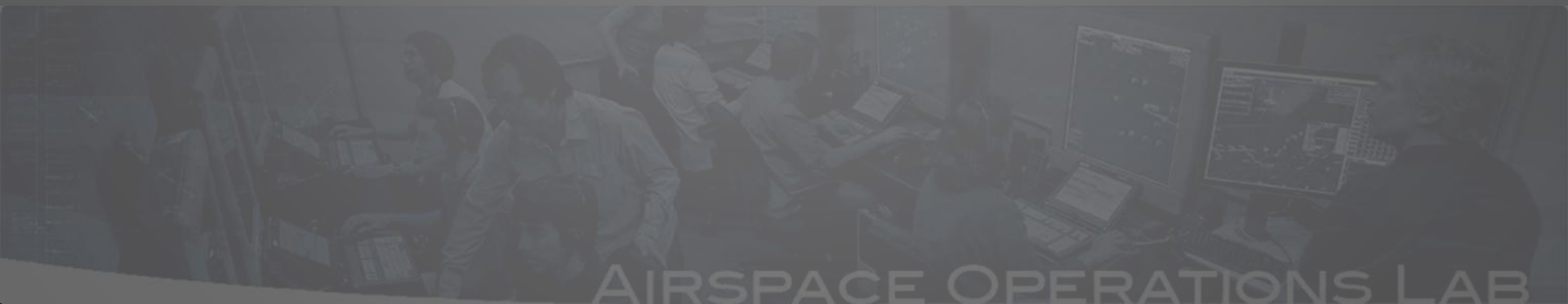
- Airspace design
- Fast time simulation
- Data analysis



Wednesday 8/4 1300 hrs AIAA-2010-8364
Graphical Specification of Trajectory Modification Options in TRAC **T. Callantine**

Multi Aircraft Control System (MACS)

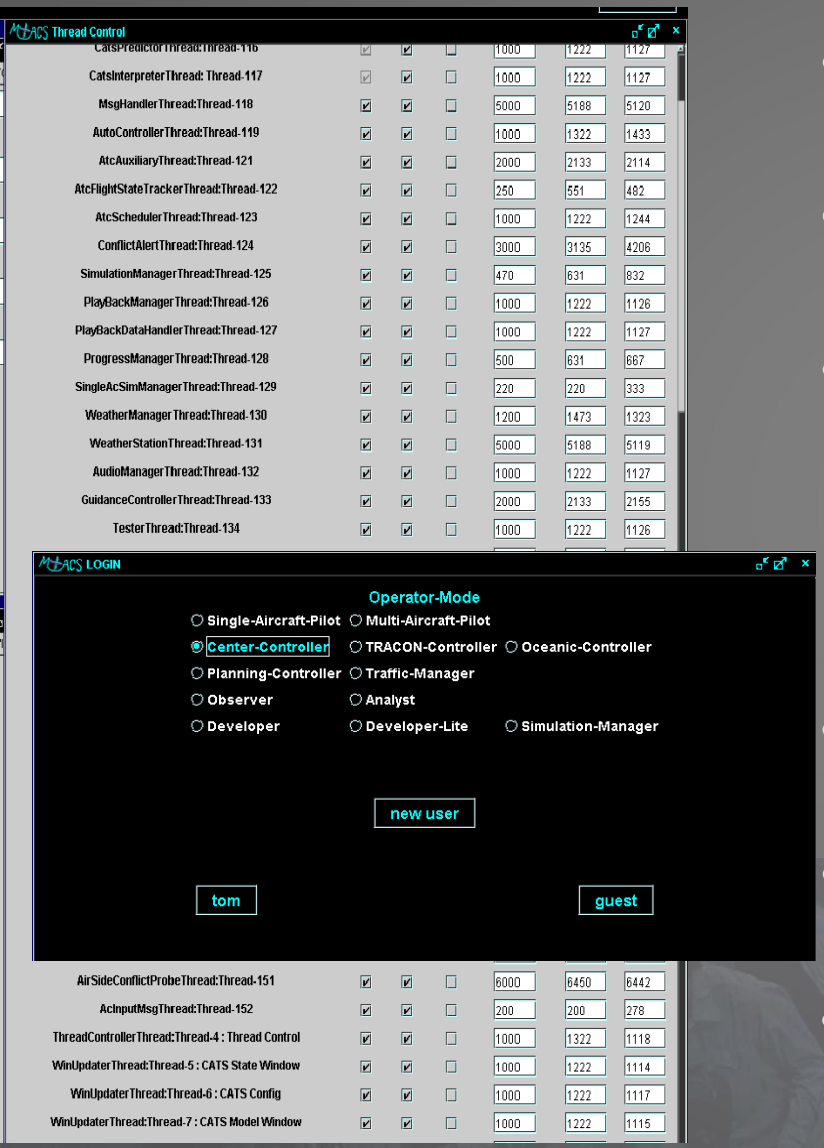
SOFTWARE



MACS Software (state 2010)

- 415,000 Source Lines of Code (JAVA)
- 2230 files
- Up to 194 parallel threads
- Unique automatic thread monitoring and restart
- Same software used at all MACS stations in a simulation
- Standalone version provides all capabilities of distributed simulation
- Very robust and scalable:
  E.g. experiment runs in 2010 of 3 hour length, 3000+ aircraft, 16 controllers and 10 pilots

Basic Software Architecture

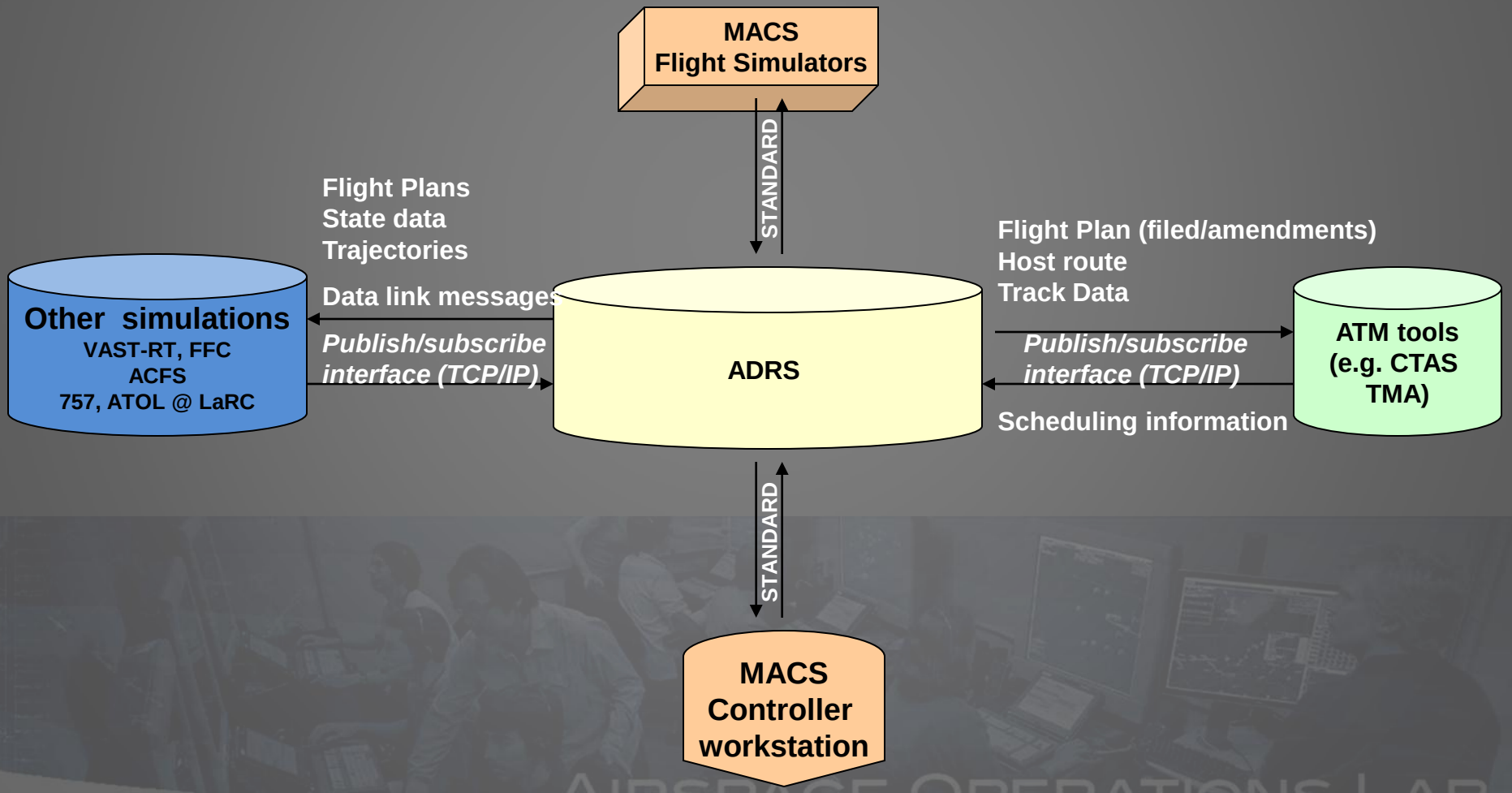


- Each MACS station runs the identical software independently
- 1 of 12 operator modes can be selected
- Only those threads and windows are started that are required for a particular operator mode
  - Low: TRACON-Controller:
  - High: Developer:
- Thread Management Process handles 150 – 200 threads
- Each functionality and each window is controlled by it's own thread
-

MACS Interface with Other Systems

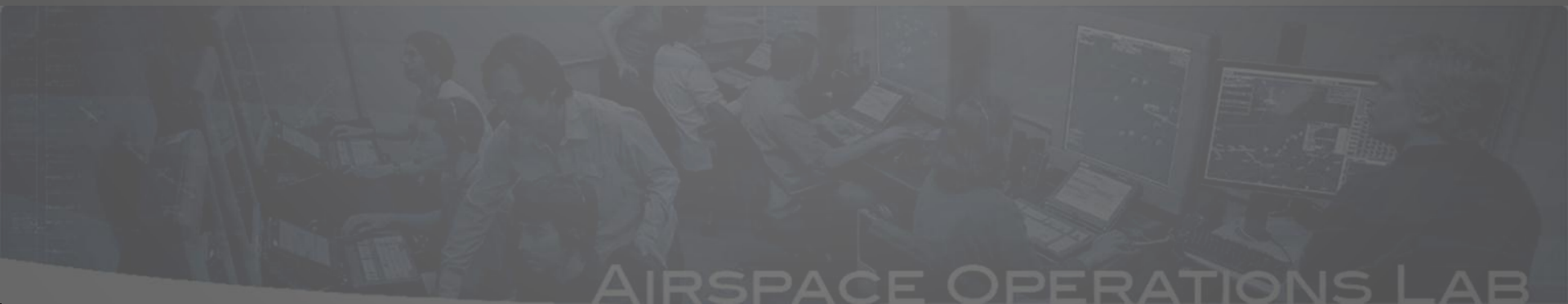
All communication is handled by one or more networked ADRS processes

The ADRS provides publish/subscribe interfaces for MACS, other simulators and tools and maintains the entire state of the simulation



Multi Aircraft Control System (MACS)

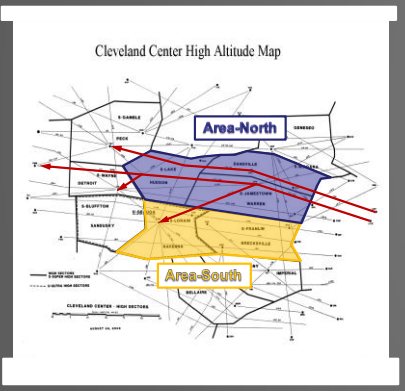
RESEARCH EXAMPLES



Recent Research in the AOL (2010-2011)

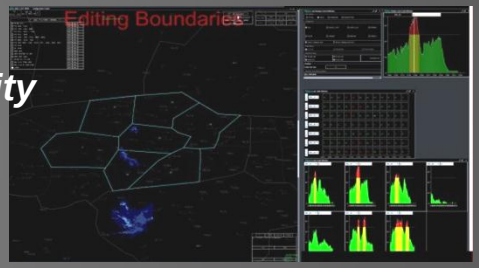
Flow Based Trajectory Management

Use tools and procedures to develop and coordinate trajectory clearances that span multiple sectors, meet traffic management objectives and provide user benefit



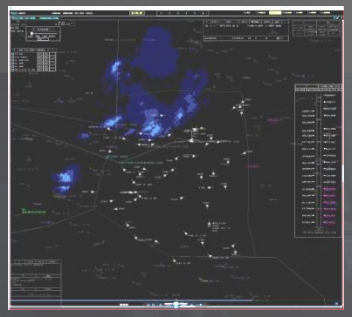
Flexible Airspace Management

Dynamically change airspace to distribute capacity more evenly between sectors



Corridors-In-The-Sky

Use flow corridors for dominant homogeneous flows to increase airspace throughput



Separation Assurance/Functional Allocation

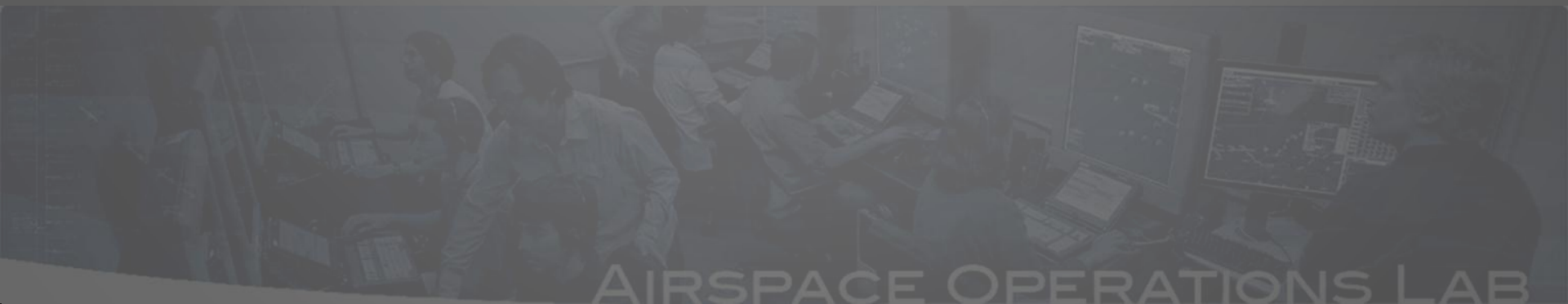
Use automation to manage aircraft separation to achieve much higher airspace capacity than today

Controller Managed Spacing

Use tools, displays and procedures to enable Optimized Profile Descents with High Throughput

Multi Aircraft Control System (MACS)

WORKSHOP



What to expect from this workshop

- Overview over MACS capabilities
- Instructions on basic installation and configuration
- Detailed discussions on commonly used functions (Center/TRACON, pilot)
- Discussion of scenario and weather Editor
- Data collection and analysis
- Opportunity for questions

Day 1 schedule

- 8:30am – Intro and MACS overview
- 10:00 am – *15 min break*
- 10:15am – Getting started with MACS
- 11:30am – How to prepare and run a simulation
- 12:45pm – *LUNCH*
- 1:45pm – Multi aircraft flight deck overview
- 3:15pm – *15 min break*
- 3:30pm - ATC overview
- 4:45pm – Research community MACS usage
- 5:30pm – End Day 1

**All presentations are followed by a 15-30 minute Q&A session*

Day 2 schedule

- 8:30am – Scenario editor and convective weather editor
- 9:45am – *15 min break*
- 10:00am – MACS data output and analysis
- 11:15am – TRAC overview
- 12:30 – *LUNCH*
- 1:30pm – MACS development overview
- 2:45pm – *15 min break*
- 3:00pm – MACS Q&A with AOL team (parallel sessions)
- 5:30pm – End Day 2

**All presentations are followed by a 15-30 minute Q&A session*

What else to expect from this workshop

- INFORMATION OVERLOAD
- VARIOUS ITEMS TO TAKE HOME
- Many More Questions ….

The MACS-Workshop Team

AOL Presenters:

- Connie Brasil
- Chris Cabrall
- Todd Callantine
- Sarah Gregg
- Al Globus
- Jeffrey Homola
- Rick Jacoby
- Vick Kelkar
- Michael Kupfer
- Joey Mercer
- Tom Prevot
- James Wong

Many additional thanks to

- Holly Latta
- Robie Remple
- Phil So